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⑥ Decision-Making and
Training Techniques for
Command and Control Systems.
Part I. Overview of Research.

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<p>An analysis of decision-making and command and control situations was conducted in order to (a) identify decision-making skills required to command and control ongoing combat situations and (b) determine relevant training procedures. Training objectives were developed for the demonstration model of the Combined Arms Tactical Training Simulator (CATTs). General-level terminal performance objectives in terms of actions, conditions, and</p>										
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standards were developed. Tests of the suitability of the demonstration model of CATTs as a training system were prepared. A literature review served as background for investigation of the production of fragmentary orders during the execution of tactical operation orders. Conclusions were: (a) Terminal performance objectives are an initial step of training development for the CATTs concept; (b) further training development is needed before training can be implemented in CATTs; (c) the developed model for the production of combat fragmentary orders has potential applicability to a range of combat situations; (d) the model can provide a basis for improving the effectiveness of the production of fragmentary orders.

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SUMMARY AND CONCLUSIONS

MILITARY PROBLEM

Technological advances in such areas as firepower, mobility, and communications have increased the capabilities of the commander and his staff for successfully executing combat operations. These advancements have also increased the complexity of command. The concept of the Combined Arms Tactical Training Simulator (CATTS) was advanced as a means for preparing command groups to command and control the execution of tactical operations under the conditions of the modern battlefield. As the concept evolved, training personnel assisted by a computer would develop simulated tactical situations that would realistically approximate the conditions of combat and afford command groups the opportunity to cope with the varying and complex problems that can arise under such conditions. In accordance with the developmental plan for CATTS, a demonstration model has been under development and is to be used to determine the feasibility of the training concept of CATTS.

RESEARCH PROBLEM

Exploratory research had indicated that research on decision-making skills and training techniques could provide a basis for contributing to the development of CATTS. Accordingly, Work Unit DECIDE was initiated to accomplish the following two research objectives:

- (1) To conduct an analysis of decision-making and command and control situations in order to (a) identify decision-making skills required to command and control ongoing combat situations and (b) determine relevant training procedures.
- (2) To assist in the development of CATTS.

This part of the report provides an overview of the work undertaken to accomplish the two research objectives. The principal results of this research—terminal performance objectives and a model for the production of combat orders—are summarized in this volume, and reported in more detail in the Part II and Part III volumes.

RESEARCH ACTIVITIES

The approach planned for research on decision making entailed a review of literature on decision making, development of a model of decision making, and inference of decision-making skills on the basis of the model. Because of changes in the priorities of Work Unit DECIDE toward increased support of the development of CATTS, a model of decision making was not developed. The reviewed literature, however, served as background for investigation of a more limited area related to decision making—the production of fragmentary orders during the execution of tactical operation orders. Data concerned with order production were collected by observing the activities of a battalion-level command group in a tactical operations center during an Operational Readiness Training Test and by analyzing transcripts of communications during an indoor command post exercise. Based on these data, a model for the production of fragmentary orders during combat was formulated.

The development of CATTS was assisted in two principal ways. The first involved the development of training objectives for the demonstration model of CATTS. Several

approaches were investigated and modified prior to the development of terminal performance objectives. The approach finally adopted was based on guidance from the Training and Doctrine Command on performance areas necessary for effectively coping with problems on the modern battlefield. This list served as a basis for the development of general-level terminal performance objectives in terms of actions, conditions, and standards.

The second major form of assistance involved preparation of tests of the suitability of the demonstration model of CATTs as a training system.

RESULTS

The principal results of Work Unit DECIDE consist of the terminal performance objectives for the demonstration model of CATTs and a model for the production of fragmentary orders.

Terminal Performance Objectives

Terminal Performance Objective 1. Prevent unanticipated enemy actions by collecting information about the enemy, evaluating the information with respect to the tactical situation, and using it effectively.

Terminal Performance Objective 2. Recognize features in the area of operations (e.g., avenues of approach, key terrain features) and use their advantages and disadvantages to enhance the capabilities of own forces.

Terminal Performance Objective 3. Determine the enemy's most probable course of action.

Terminal Performance Objective 4. Identify and interpret the fires of enemy weapons.

Terminal Performance Objective 5. Identify enemy actions, based on available information, and take appropriate actions.

Terminal Performance Objective 6. Identify enemy feints, ruses, and deceptions.

Terminal Performance Objective 7. Prevent unanticipated enemy actions by taking measures to counter the gathering of information about own situation.

Terminal Performance Objective 8. Employ organic and supporting fires to maximize their capabilities.

Terminal Performance Objective 9. Implement improvisation when the conventional methods of employment of tactical formations, weapons, and equipment would not be effective.

Terminal Performance Objective 10. Identify, under conditions of unanticipated catastrophic equipment losses and casualties, remaining capabilities and vulnerabilities and take immediate action.

Terminal Performance Objective 11. Take effective actions in situations for which tactical doctrine is insufficient or inappropriate.

Terminal Performance Objective 12. Effect timely resupply in personnel, supplies, and equipment to minimize interruptions in executing tactical operations.

Terminal Performance Objective 13. Maintain continuous and secure communications.

Terminal Performance Objective 14. Communicate with subordinates and among members of the command group in a fashion that produces intended responses.

Terminal Performance Objective 15. During combined arms operations, alter the scheme of maneuver and/or plan of fire support when either or both would be ineffective due to unanticipated conditions associated with the enemy, weather, and terrain.

Model for Order Production

The model of order production that was developed describes the various sequences of performances of the battalion commander or selected members of his staff as the individual is engaged in the production of a fragmentary order in combat.

Initially, three functions of the model were identified: Instigation, Decision Making, and Dissemination. Instigation involves the recognition of conditions that initiate behaviors leading to decisions. Decision Making concerns the selection of a course of action to deal with the situation. Dissemination reflects the transmission of an order to the appropriate recipients.

Five processes that fulfill these three functions were identified: Sensing, Evaluating, Considering, Deciding, and Communicating. Sensing involves the acquisition of information and the perception of an instigating condition. Evaluating is an analysis of the instigating conditions relevant to mission accomplishment. Based on the analysis, the activities in the process of Considering deal with identification of effective courses of action. The process of Deciding refers to the selection of a course of action. Through the process of Communicating, the decision is disseminated to the appropriate recipients.

The result of the final process is an order intended to affect either the internal or the external environment of the battalion. Sequences of performances representing each process in the model were also developed and described.

CONCLUSIONS

The conclusions are based on the research reported in more detail in Part II and Part III of this report:

(1) The terminal performance objectives that were developed are an initial step of training development for the CATTS concept. These objectives constituted the basis of the specific performance objectives for the demonstration model of CATTS.

(2) Further training development must be undertaken before training can be implemented in CATTS. This additional work, which will include the development of training content and approaches, needs to take into account features of the terminal performance objectives, the training purpose of CATTS, and the capabilities of remaining components of the system.

(3) The developed model for the production of combat fragmentary orders has potential applicability to a range of combat situations. Further investigation of the model is required to determine its validity and generalizability.

(4) This model, if validated and applied, can provide a basis for improving the effectiveness of the production of fragmentary orders.

(5) The model can contribute to the development of training materials and programs for improving production of combat fragmentary orders by assisting in (a) specification of performance requirements for members of the command group, (b) identification of requisite knowledges and skills, (c) selection of materials for inclusion in training programs, and (d) the design of training programs, especially training simulations.

PREFACE

This report describes work completed by the Human Resources Research Organization in Work Unit DECIDE, Decision-Making and Training Techniques for Command and Control Systems. Work Unit DECIDE was originally established in July 1972, under the sponsorship of the U.S. Army Infantry School (USAIS), Fort Benning, Georgia, and evolved from Exploratory Research 87 (ER 87). The objectives of the Work Unit have been to (a) identify decision-making skills and training techniques and (b) assist in the development of the Combined Arms Tactical Training Simulator (CATTS).

The report is presented in three parts. Part I provides an overview of the work. The remaining two parts describe two of the principal products of the Work Unit; Part II, the development of terminal performance objectives for the demonstration model of CATTS; Part III, research bearing on decision making—order production at the battalion level.

Work Unit DECIDE was conducted at HumRRO Central Division, Columbus Office, Columbus, Georgia. The work was initiated under the direction of Dr. T.O. Jacobs and completed under the direction of Dr. Joseph A. Olmstead, the current Director of the Columbus Office. Theodore R. Powers and Dr. Trueman R. Tremble, Jr. successively served as Work Unit Leaders. Other primary participants in this research were COL (Ret) Arthur J. DeLuca, Dr. Larry L. Lackey, and Jeffery L. Maxey.

Military support was provided by the U.S. Army Infantry Human Research Unit, Fort Benning, Georgia. LTC Chester I. Christie was Chief at the inception of the work; he was succeeded by LTC Willys E. Davis and LTC Robert G. Matheson. Specialists Wayne Carpenter and James M. Tripp, also of the Human Research Unit, contributed to the early research on decision making. Military guidance for assistance in the development of CATTS was provided by MAJ Albert R. Amos, Jr. and MAJ David Fried of USAIS during the earlier phases of the Work Unit. Subsequently, the development of training and testing was accomplished in close working relationship with the CATTS Directorate, USAIS, under the direction of LTC Glenwood E. Jones, Jr.

HumRRO research for the Department of the Army under Work Unit DECIDE was conducted under Contract DAHC19-73-C-0004. Army training research is conducted under Army Project 2Q062I07A745. The DECIDE work was conducted under the sponsorship of the U.S. Army Research Institute for the Behavioral and Social Sciences, with James Baker serving as the technical monitor.

TABLE OF CONTENTS

PART I

	Page
Summary and Conclusions	1
Preface	5
Introduction	11
Military Problem	11
Research Problem	11
Research Activities	12
Research on Decision Making	12
Assistance to CATTs	13
Training for CATTs	14
Operational Testing	16
Results and Implications	18
Terminal Performance Objectives	18
Model for Combat Order Production	19
Functions	19
Processes	19
Categories of Activities	21
Input and Output	21
Implications	21
References	25

List of Illustrations

Figure		
1	Model of the Production of a Combat Order	20

**Decision-Making and
Training Techniques for
Command and Control Systems**

Part I. Overview of Research

Part I
INTRODUCTION

MILITARY PROBLEM

Technological advances in such functional areas as firepower and mobility have increased the commander's capabilities for successfully implementing combat operations. At the same time, these advances have also increased the complexity of command. One such advance was the original impetus for the Combined Arms Tactical Training Simulator (CATTS). That is, problems resulting from the adaptation of the helicopter as a command and control center for airmobile operations pointed out the need to train potential battalion commanders and staff officers in the execution of these operations. It was later determined that technological advances had created similar needs for training in commanding and controlling the execution of infantry and mechanized operations. The concept of CATTS was accordingly enlarged to cover infantry and mechanized operations.

According to the CATTS concept, computer-assisted simulation would offer a satisfactory solution to the training problem. More specifically, simulation in CATTS would provide the opportunity to create a variety of tactical environments that realistically approximate battlefield conditions. In turn, battalion command and staff officers would be required to cope with the varying problems that could arise under such conditions. In that manner, command and staff officers could obtain training experiences that could otherwise be obtained only by participation in actual combat. According to the plan for implementing this concept, a demonstration model of CATTS would be developed first in order to determine the feasibility of the concept.

RESEARCH PROBLEM

Under the sponsorship and direction of the U.S. Army Infantry School (USAIS), Exploratory Research 87 (ER 87) was undertaken in FY72 to determine the feasibility of research that could contribute to the development of CATTS. It was concluded that research structured at two levels would make such a contribution. At a general level, research into decision making would provide basic information that would be applicable to commanding and controlling the execution of tactical operations. Partly based on this information, direct assistance could be provided in the development of training in CATTS. Accordingly, Work Unit DECIDE was established in FY73 to accomplish the following two research objectives:

(1) To conduct an analysis of decision-making and command and control situations in order to (a) identify decision-making skills required to command and control ongoing combat situations and (b) determine relevant training procedures.

(2) To assist in the development of CATTS.

This three-volume report describes the research accomplished in terms of these two objectives. The first volume provides an overview of the research that has included a review of literature on decision making, an investigation of order production in battalion-level command groups, and the development of training and test plans for the demonstration model of CATTS. Two of the products of the Work Unit—terminal performance objectives for CATTS and a model of order production—are also reviewed. Research resulting in these two products is reported in greater detail in the other two volumes of the report.

RESEARCH ACTIVITIES

The original approach for identifying decision-making skills stemmed from the results of ER 87. This approach involved a review of literature on decision making in order to formulate a model that would allow the inference of requisite decision-making skills. Work on the model was to be relevant to CATTS. The model itself, however, was not to be so closely tied to CATTS that its application would be limited to CATTS. Because of the need for increased assistance in the development of CATTS, progress on a model of decision making was limited to the assembly and review of literature on decision making. The literature review provided a background for the completion of research on a related phenomenon, the production of combat orders at the battalion level. Assistance to CATTS has involved the development of both terminal performance objectives and plans for testing the suitability of CATTS as a training system.

RESEARCH ON DECISION MAKING

The review of literature on decision making, undertaken to provide a basis for formulating a model of decision making, was extended to identify pertinent variables, their relationships, and an appropriate framework. Subsequent to the review, research was focused on order production at the battalion level.

As an initial activity, the literature review produced during ER 87¹ was expanded. The literature was also examined for information on the problem with which Work Unit DECIDE was concerned—decision making in command and control settings. These efforts led to the suggestion that the earlier review had largely concentrated on decision making defined as a choice between alternatives. However, the literature itself tended to indicate that the review should not be limited by such a strict definition of decision making. Rather, it seemed more appropriate to view decision making within the larger context of thought processing.

Adair,² for example, asserted that decision making is only one aspect of thinking. Taylor³ also pointed out that decision making is a form of thinking that is distinguishable from other mental activities—creativity and problem solving—primarily on the basis of its end product and not in terms of the processes involved. Finally, distinctions are often made among the components of decision situations. Rodgers,⁴ for example, identified the following seven components: (a) goal, (b) criteria for evaluating goal achievement, (c) decision maker's estimate of the environment, (d) alternative courses of action, (e) expected outcomes of alternative actions, (f) probabilities of states of nature, and (g) values placed on expected outcomes. If such a view of decision making were entertained, the literature review would need to be comprehensive for each component. These considerations thus led to an expansion of the scope of the review so that a variety

¹ W. Carpenter, and J. Tripp. "Decision Making Theory and Practice in Command and Control Simulators," HumRRO working paper, July 1972.

² J. Adair. *Training for Decisions*, McDonald, London, 1971.

³ D.W. Taylor. *Decision Making and Problem Solving*, Technical Report 9, ONR Contract NONR 609 (20) (NR 150-166), Yale University, New Haven, Connecticut, September 1963.

⁴ D.J. Rodgers. *Decision Making. Human Factors and Training, Information Systems Operation*, General Electric Company, Washington, D.C., June 1960.

of cognitive activities such as problem solving, concept formation, information processing, and thought processing could be included in order to achieve a more comprehensive understanding of the cognitive processes involved in decision making.

Examination of the earlier review, in terms of the research problem, also indicated the appropriateness of gathering information about decision making in organizational settings. That is, decision making in command and control settings is a phenomenon of interest because such decisions have an impact on individuals and groups within organizations whose interdependent efforts lead to the accomplishment of organizational goals or missions.

Moreover, not only do command decisions influence others as implied by a structural view of organizations, but organizational phenomena and processes can influence command decisions as well. Evidence suggests, for instance, that the quality of information communicated throughout an organization is positively correlated with the quality of decisions made in it.¹ Also, Shull, Delbecq, and Cummings² implied that decisional problems confronting decision makers in organizational settings will vary with the structure imposed on the problems by the organization. The same researchers maintained that organizational decision-making strategies will be tailored to fit these varying types of problems. Such findings suggested that organizational processes can alter decision-making strategies and outcomes. More generally, they indicated the need to orient the review, and related research, to decision making in the context of the organization.

Before the expanded review was completed and integrated into a model of decision making, USAIS sought assistance in the development of plans for testing the effectiveness of CATTS as a training system. The response to this request necessitated a temporary suspension of the work on decision making. Upon resumption, the research centered on the production of combat orders at the battalion level. This entailed observing the activities of a command group in a tactical operations center during an Operational Readiness Training Test and analyzing transcripts of communications during an indoor command post exercise as a basis for the development of a model for order production. The model concerns the production of fragmentary orders during the execution of tactical operations and is summarized in the results of this volume. In Part III of this report, the research on order production is reviewed in detail.

ASSISTANCE TO CATTS

The assistance provided in the development of CATTS has taken several forms. In the initial stages of Work Unit DECIDE, USAIS frequently requested information about human factors; consequently, much effort was spent in solving day-to-day problems identified by USAIS. Since the inception of the Work Unit, substantial effort has also been directed toward the development of training for CATTS, in particular toward the development of training objectives for the demonstration model. Consequently, the terminal performance objectives for this version of CATTS represent a major product of Work Unit DECIDE. More recently, assistance has been provided in the development of plans for testing the effectiveness of the system as a trainer.

¹ Joseph A. Olmstead, Harold E. Christensen, and Larry L. Lackey. *Components of Organizational Competence: Test of a Conceptual Framework*, HumRRO Technical Report 73-19, August 1973.

² F.A. Shull, Jr., A.L. Delbecq, and L.L. Cummings. *Organizational Decision Making*, McGraw Hill, New York, 1970.

Training for CATTS

Since its inception, Work Unit DECIDE research has been structured so that assistance in the development of training for the demonstration model of CATTS could be provided. This effort has largely centered on the development of training objectives. This developmental work has undergone five stages. The last stage was based on guidance from the Training and Doctrine Command (TRADOC) which both altered and clarified the objective of training in CATTS. Based on this guidance, terminal performance objectives were developed. Additional work has involved the identification of methods and materials for the implementation of training in CATTS.

Four approaches were investigated and then modified before an approach was settled upon and terminal performance objectives were developed. The first three approaches are described more thoroughly elsewhere.¹ The first approach resulted in training objectives that were based on the specified and implied tactical objectives of a battalion in the types of tactical operations that would be patterned after the CATTS' mathematical model. In the second approach, organizational processes with demonstrated influence on problem solving in a simulated tactical exercise were combined with tactical doctrine and principles as the basis for identifying training objectives. The third approach represented a refinement of the preceding one. That is, performance objectives were to be based on, first, the assigned functional duties of the members of the command group (rather than tactical doctrine) and, second, the performance of five supervisory processes extracted from a summary of literature relevant to the execution phase and to commanding and controlling. (It should be noted that the results of the first step were presented in a working concept paper transmitted to the CATTS Project Officer at USAIS who, in turn, distributed the paper to potential developers of the hardware and computer software of the system.)

Modifications of each of the first three approaches were made in order to achieve one or more of the following: (a) orientation on performances in the job setting as opposed to an orientation on doctrine and principles, (b) specifiability and measurability of the achievement of a performance, and/or (c) a more deliberate application of systems engineering approaches to training development. The emphasis on the performances of the members of the command group as they supervise an ongoing tactical operation (which emerged from the first three approaches) was reflected in the fourth approach.

The fourth approach, which is described more completely in Part II, was developed after the training problem had been re-analyzed. This analysis led to three conclusions about training in CATTS. First, training in CATTS should focus on general-level performances and skills applicable to the dynamic and varied tactical problems characterizing combat. Second, training should pertain to the jobs of command groups involved in the supervision of ongoing combat operations. Third, the demonstration model of CATTS should be a team trainer.

Based on these conclusions, a modified systems engineering approach was proposed. According to it, two interrelated sets of training performance objectives² would be developed. The first set would stem from tactical concepts judged to be important in the execution of tactical operations in desert settings. The term "tactical concept" referred to

¹Truman R. Tremble, Jr., T.O. Jacobs, and Arthur J. DeLuca. "Decision Making and Training Techniques for Command and Control Systems," HumRRO Interim Report D4-74-17, June 1974.

²When this approach was advanced, it was recognized that it was mandatory to arrive at the desired outcomes of training as quickly as possible in order to contribute to the total developmental effort of CATTS. It seemed more appropriate to label the end results of training as performance objectives, rather than training objectives, since time would not allow the specification of the underlying structure of knowledges, skills, and attitudes.

principles or beliefs on how tactical operations should be conducted in terms of such functions as firepower, information acquisition, mobility, and engagement. The second set would consist of categories of performances that had been demonstrated or hypothesized to be involved in decision making and problem solving. Tasks listed in job-task inventories for the battalion commander, intelligence officer, operations officer, and fire support coordinator would be related to the categories of performances and used as the media for training.

The approach just described would have led to performance objectives applicable to performance in a variety of settings. Through the use of the job-task inventories and training scenarios for CATTs, the performance objectives could have been translated into specifiable performances, performance outcomes, and means for their evaluation. Guidance received from TRADOC resulted in suspension of work related to this approach so that performance objectives responsive to the guidance could be developed prior to the delivery of the hardware and computer software of the system.

In early FY75, TRADOC provided guidance that both changed and specified more clearly the objectives of training in the demonstration model of CATTs. The concept paper for CATTs had indicated that the objective of training was commanding and controlling. The guidance received by TRADOC, however, emphasized the need to prepare the soldier to cope with the changing, adverse, and often unanticipated conditions of the modern battlefield. It was directed that the objectives of training in CATTs should be congruent with this need.

The objectives indicated by the guidance may be summarized as follows:

- (1) To increase the command group's understanding of the conditions characterizing the modern battlefield; and
- (2) To increase the command group's ability to fight under these conditions.

Examples of training areas were provided as part of the guidance (see Part II, Appendix A).

Following consultation with the direct user agency of CATTs, an approach was determined for developing performance objectives that conformed to TRADOC's guidance and that incorporated, to the extent feasible, those training areas included in the guidance. According to the approach, performance objectives would consist of generalized performances of a command group during the execution phase of a combat operation. The action component of the performance objective would describe categories of performances in the sense that the action could be manifested in somewhat different ways under different conditions. The condition component would consist of dimensions or variables that would characterize tactical settings appropriate for the occurrence and measurement of the action. The standards were to outline at a general level appropriate means for evaluating any representative action under any set of conditions. The standards were also to be of such a form that they could be translated into objective measures.

The approach and the resulting terminal performance objectives are described in greater detail in Part II of this report. These objectives were the basis of the performance objectives eventually selected for training in the demonstration model of CATTs.

In addition to performance objectives, assistance in the development of training has taken two other forms. Preliminary steps were taken to define an approach for training in the demonstration model of CATTs. Upon completion, the approach is to present a framework for the future design of training. As emphasized in Part II, additional training development for CATTs needs to take into account other system components, especially the hardware and computer software developed prior to and independently of plans and materials for training. In conjunction with the direct user agency of TRADOC, plans were also made and partly implemented for training materials in the form of a controller manual or handbook. As originally designed, the completed handbook would be used to prepare potential controllers to operate the hardware and computer software as

equipment, to conduct tactical exercises in general, and to implement the specific training and test exercises planned for the demonstration model of CATTS.

Operational Testing

In the Spring of 1973, the Infantry School requested assistance in the development of a plan for Operational Test I (OT I) of CATTS. At that time, the requested assistance was described in terms of the development of a plan for testing the training effectiveness of the system. In response to the request, an analysis was undertaken to determine the requirements for providing the assistance. In conjunction with the CATTS Operational Test Officer at USAIS, an initial set of test objectives and a research plan were outlined. Although changes in the original test plans for OT I have been proposed, the general orientation of the original plans has not been materially altered.¹

To determine what would be required to provide assistance in developing a plan for OT I, four sources were reviewed. These consisted of the plan that coordinates operational and developmental testing of the system,² selected Army regulations bearing on testing, the concept paper for CATTS,³ and the specifications for the hardware and computer software.⁴ This search led to several conclusions about OT I and the work required to plan for it. That is, OT I should be oriented toward the user and not the engineering specifications. The results of such a test (or tests) would be used to make judgments about the military worth and continued development of the system. Such judgments would require information about the overall effectiveness of the system and, in addition, factors influencing the system's effectiveness.

Although the purposes of the system had not been expressed in consistent, clear, or precise terms, the various statements about the purposes of CATTS did seem to converge on the following two points: (a) Simulation in CATTS was to create environmental conditions that realistically portray those experienced by battalion commanders and selected staff officers during the conduct of actual combat operations; and (b) simulated tactical operations were to afford players the opportunity to perform as do battalion commanders and selected staff officers during the conduct of actual tactical operations.

The results of the review also emphasized that CATTS would be a system comprised of a number of subsystems that together would result in the total configuration. These subsystems should be examined in OT I in order to obtain information about the factors that influence the effectiveness of the total system.

Based on these conclusions, a general approach for OT I was developed. The purpose of OT I would be to determine whether CATTS achieves its purposes in a user setting. Before information about the effectiveness of the system would be collected, subsystems would be examined to identify and offset problems associated with their operation. Arrangements with the Operational Test Officer were also established for development of the plan. The Test Officer was to arrive at system-level test objectives in terms of the purposes or uses of the system. As part of Work Unit DECIDE, the CATTS system was to be analyzed to determine candidate test objectives based on characteristics of the

¹ During the preparation of this report, OT I was cancelled because of difficulties associated with the hardware and computer software. The footnoted statement accurately describes the status of the plans for OT I at the time of its cancellation.

² U.S. Army Training Device Agency. "Coordinated Test Program for Combined Arms Tactical Training Simulator Device 16A3" (Revision 2), Orlando, Florida, March 1973.

³ U.S. Army Infantry School. *Training Device Requirement for the Combined Arms Tactical Training Simulator*, Fort Benning, Georgia, March 1973.

⁴ U.S. Naval Training Equipment Center. *Specification for Trainer: Combined Arms Tactical Training Simulator Phase I, Part 1 Device 16A3*, Orlando, Florida, January 1973.

subsystems of CATTS that could influence the effectiveness of the total system. After reviewing the method used to identify test objectives for subsystems, the development of the test plan itself will be described.

The analysis of CATTS was predicated on the assumption that factors influencing the effectiveness of a complex and innovative system like CATTS would partly stem from factors in its various subsystems and/or their combination. The analysis thus was undertaken to identify operational issues related to components of the system, where "operational issue" was defined as a consideration critical to the functioning of the system. The analysis involved several steps:

Step 1. Identifying stimuli that would directly impinge on players during a simulated tactical operation. In the original analysis, the engineering specifications for CATTS and the winning contractor's proposal¹ were used to identify six sets of stimuli.

Step 2. Identifying the essential and desired characteristics of the stimuli from the concept paper for CATTS.

Step 3. Providing a framework for specifying functions for each set of stimuli, which relied upon the general notion of the purpose of CATTS: to train battalion commanders and staffs in commanding and controlling ongoing combat operations in the context of a realistic tactical setting.

Step 4. Deriving operational issues for each set of stimuli based on their characteristics (Step 2) and their functions (Step 3).

After operational issues for stimuli directly impinging on players had been derived, background events that would lead up to or produce the direct stimuli were similarly analyzed. As in Steps 2 and 3, characteristics of each background event and its functions in the user context were identified. Before operational issues were identified, a third source was considered: the controllers who, by interacting with players and the computer, were to create training exercises in CATTS. That is, background events seemed to involve one or more performances of controllers in conjunction with hardware and the information inputs and outputs related to the computer. Thus, the performances of controllers in operating the hardware and in manipulating information were used as the third source of operational issues for background events.

Test objectives based on the operational issues and system-level objectives developed by the CATTS Operational Test Officer provided the initial framework for development of a research plan for OT I. For each objective, a research method was outlined. Assistance in the development of methods was provided by identifying candidate methods and then finalizing them in close coordination with the Operational Test Officer. The test objectives and methods were then reviewed by several Army agencies. Based on the results of the reviews, Work Unit DECIDE participated in revising and expanding the test plan. The latter revision served as the basis of a Test Design Plan for OT I that was forwarded to and distributed by TRADOC.

In summary, Work Unit DECIDE assisted in the development of a test plan for OT I by arriving at an approach or framework for the test, identifying test objectives, and outlining test methods. This assistance resulted in a Test Design Plan that was transmitted to and distributed by TRADOC. It should be noted that after the Test Design Plan had been staffed, it was again revised. The framework established earlier continued to be reflected in later versions; the test plan has continued to focus on subsystems of CATTS and their preparation prior to tests of the training effectiveness of the CATTS system as a whole. In addition, the earlier analysis of the CATTS system was updated as more complete and accurate information became available. It has also contributed to the development of training and test materials.

¹ TRW Systems Group. "A Proposal for a Combined Arms Tactical Training Simulator (CATTS): Volume I, Technical Approach," Redondo Beach, California, March 1973.

RESULTS AND IMPLICATIONS

While several interim products have resulted from Work Unit DECIDE, the principal results are, first, the terminal performance objectives for the demonstration model of CATTS and, second, a model of order production. These two sets of results will be summarized in this section. They are reported in greater detail in the Part II and Part III of this report.

TERMINAL PERFORMANCE OBJECTIVES

The 15 terminal performance objectives developed for the demonstration model of CATTS include statements of actions, conditions, and standards. As review of this summary will indicate, many of the statements of actions actually describe multiple actions. To reduce the complexity and generality of such performance objectives, "enabling objectives" were derived. In this volume, the 15 terminal performance objectives are summarized as follows in terms of the statements of action:

Terminal Performance Objective 1. Prevent unanticipated enemy actions by collecting information about the enemy, evaluating it with respect to the tactical situation, and using it effectively.

Terminal Performance Objective 2. Recognize features in the area of operations (e.g., avenues of approach, key terrain features) and use their advantages and disadvantages to enhance the capabilities of friendly forces.

Terminal Performance Objective 3. Determine the enemy's most probable course of action.

Terminal Performance Objective 4. Identify and interpret the fires of enemy weapons.

Terminal Performance Objective 5. Identify enemy actions, based on available information, and take appropriate actions.

Terminal Performance Objective 6. Identify enemy feints, ruses, and deceptions.

Terminal Performance Objective 7. Prevent unanticipated actions of the enemy by taking measures to counter the enemy's gathering of information about the situation of friendly forces.

Terminal Performance Objective 8. Employ organic and supporting fires to maximize their capabilities.

Terminal Performance Objective 9. Implement improvisation when the conventional methods of employment of tactical formations, weapons, and equipment would not be effective.

Terminal Performance Objective 10. Identify, under conditions of unanticipated catastrophic equipment losses and casualties, remaining capabilities and vulnerabilities and take immediate action.

Terminal Performance Objective 11. Take effective actions in situations for which tactical doctrine is insufficient or inappropriate.

Terminal Performance Objective 12. Effect timely resupply in personnel, supplies, and equipment to minimize interruptions in executing tactical operations.

Terminal Performance Objective 13. Maintain continuous and secure communications.

Terminal Performance Objective 14. Communicate with subordinates and among members of the command group in a fashion that produces intended responses.

Terminal Performance Objective 15. During combined arms operations, alter the scheme of maneuver and/or plan of fire support when either or both would be ineffective due to unanticipated conditions associated with the enemy, weather, and terrain.

MODEL FOR COMBAT ORDER PRODUCTION

The model for order production describes the performance of a commander or member of his staff as he is engaged in the production of a fragmentary order during the execution of a combat operation order. As depicted in Figure 1, the model describes order production in terms of five components: (a) functions, (b) processes, (c) categories of activities, (d) inputs, and (e) outputs or results of order-production activities. Each of these components is reviewed in this part of the report; they are presented in greater detail in Part III. For convenience in presentation of the model, the individual involved in the production of an order is referred to as an information processor (or IP).

Functions

According to the model, three functions are sequentially fulfilled when an order is produced. The first function, referred to as Instigation, involves the recognition or detection of conditions that initiate behaviors leading to decisions. Conditions that will instigate decisions are characterized by a discrepancy either between current and desired (ideal) conditions or between future and ideal conditions. A discrepancy can arise from either or both of two sources. First, it could be command imposed; in these cases, the discrepancy could be attributed to a change in the IP's definition of ideal conditions. Second, a discrepancy could result from a change in the situation away from ideal conditions.

The second function consists of those activities involved in the identification and eventual selection of a course of action for dealing with the discrepancy. This function is labelled Decision Making.

Decisions about actions for coping with discrepancies do not necessarily lead to orders. That is, orders are produced only if a decision is encoded into media appropriate for communicating and if the encoded decision is then communicated. The third function, referred to as Dissemination, involves those activities that result in the communication of the decision.

Processes

The three functions just described are fulfilled by sequences of activities that represent five processes: Sensing, Evaluating, Considering, Deciding, and Communicating.

In the model, orders are based on decisions about actions for dealing with recognized discrepancies. The recognition of a discrepancy, therefore, is an initial occurrence in the production of a combat order. The process of Sensing subsumes those performances involved in both the acquisition of information and the detection of a discrepancy based on the information. The model suggests that in terms of decision making and order production, sensing activities continue until an instigating condition has been recognized.

After the detection of a discrepancy through Sensing, performances regarding the discrepancy center on the function of Decision Making. Three successive processes are involved. The first is Evaluating. The activities represented by this process involve an analysis of the discrepancy to determine its criticality to mission accomplishment. Based on the results of this analysis, activities represented by the process of Considering are undertaken. These activities result in the identification of courses of action that, if enacted, would

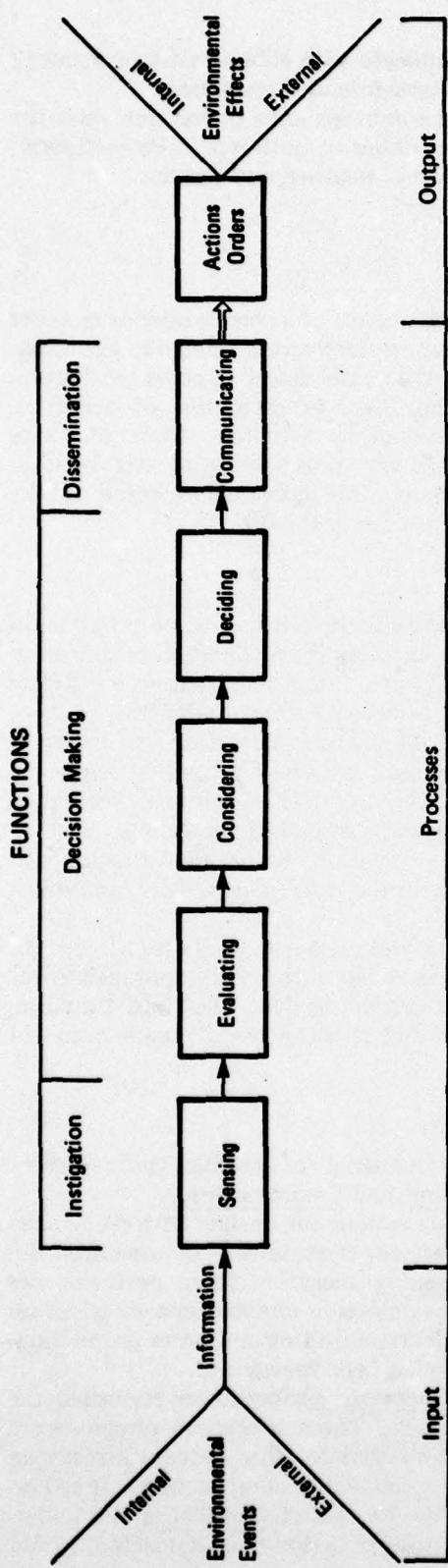


Figure 1. Model of the Production of a Combat Order

be likely to minimize or eliminate the discrepancy. Having identified possible courses of action for dealing with the discrepancy, the IP then compares them and selects the one perceived to have the greatest likelihood of success. The comparison and selection of performances comprise the processes of Deciding. This process also involves the identification of the appropriate recipients of an order. The function of Decision Making, thus, is modeled in terms of those activities that form the processes of Evaluating, Considering, and Deciding.

Dissemination, the third function, is achieved through activities subsumed by the process of Communicating. These activities include selecting the means for transmitting the decision, coding information, distributing the decision as an order, and discussing the order with recipients to obtain feedback about its receipt and current appropriateness.

The model suggests that the processes are performed in this sequence: Sensing, Evaluating, Considering, Deciding, and Communicating. Moreover, upon communicating an order, the IP re-initiates sensing activities. Activities in each process could be interrupted, and information processing about an item would be terminated prior to the production of an order. It should also be noted that the model is not intended to imply that the behavior of an IP would always be observed to conform with the sequences specified in the model. It is possible, for example, that an IP may have to cope with several discrepancies within a relatively short period of time. Under such conditions, arriving at a solution to one problem could temporarily suspend activities related to the solution of a problem identified earlier.

Categories of Activities

In Part III of the report, each process is more completely described in terms of the sequences of categories of activities comprising it. That is, each process represents one or more sequences of behaviors. The performances comprising a process are presented as categories of activities in that they describe generalized behaviors as opposed to the specific behaviors. Accordingly, the same process could be reflected in somewhat different performances appearing in somewhat different sequences.

Input and Output

Information about environmental events is an implied component of the model. Such input could describe events in the environment either external (e.g., enemy movement) or internal (e.g., own casualties) to the battalion. Information about an event could be directly acquired by the IP; alternatively, he could receive it indirectly from other individuals through oral or written reports.

The output or result of the processes in the model is a fragmentary order. It would be possible to define the results of order-production in terms of the effects that occur when an order is acted upon, obeyed, or followed. The model, however, is not comprehensive of the activities that take place between the production of an order and the effects of the order on the environment.

IMPLICATIONS

To assist in the development of CATTS, terminal performance objectives for the demonstration model of CATTS were developed. Those objectives were the basis of the objectives finally adopted for training in the demonstration model. Additional preparatory work in terms of training content and methods is needed before training can be implemented in the demonstration model. This work needs to take into account the nature

of the performance objectives and the characteristics and capabilities of other components of the CATTS system—in particular, the hardware and computer software.

The research on decision making resulted in a model for the production of fragmentary orders during combat. This model could serve as a basis for improving the production of such orders. In particular, it could contribute to the development of training programs and materials. Before the model is applied, however, further investigation is needed to determine its validity and generalizability.

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